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Perceptions of Scientific Literacy and Elementary Teacher Preparation Held by Science Professors and Science Education Professors

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The study examined the perceptions of scientific literacy and elementary teacher preparation held by science professors and science education professors. Participants were 31 professors, including 16 life and physical science professors and 15 elementary science education professors, from nine state universities in a southeastern state. Data were collected through telephone interviews and course documents. Professors, as a group, tended to define scientific literacy and its components in a comprehensive manner, which was generally consistent with the National Science Education Standards and Project 2061. However, science professors emphasized science knowledge more strongly than other components of scientific literacy; whereas, science education professors emphasized science inquiry. Although both groups indicated that elementary school teachers were generally unprepared to teach science, science professors often attributed teachers' lack of preparation to teachers themselves; whereas, science education professors often attributed it to universities. Implications for promoting scientific literacy in elementary schools are discussed.

National concerns about poor student performance in science, accompanied by the increasing need for scientific and technological knowledge and skills to participate in society, have resulted in extensive reform efforts to improve science education (American Association for the Advancement of Science [AAAS], 1989, 1993; National Research Council

[NRC], 1996; National Science Teachers Association [NSTA], 1992, 1996). These science reform efforts are characterized by a common theme of scientific literacy for all students.

National standards documents, represented by the *National Science Education Standards* (NSES) (NRC, 1996) and Project 2061 (AAAS, 1989, 1993), provide a general definition of scientific literacy and a guideline to achieve the goal of scientific literacy for all students. The NSES defines scientific literacy as "the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civil and cultural affairs, and economic productivity" (NRC, 1996, p. 22).

According to the analysis conducted by Project 2061, there is approximately 90% agreement in content standards between the NSES and Project 2061 documents (AAAS, 1996, 1997). The NSES also states, "use of Benchmarks [by Project 2061] ... complies fully with the spirit of the content standards [in the NSES]" (NRC, 1996, p. 15). Together, the NSES and Project 2061 documents define scientific literacy in a comprehensive manner (Lee, 1998; Lee & Paik, 2000; Raizen, 1998). The documents identify the components of scientific literacy in terms of what K-12 students should know, understand, and be able to do. These components include key concepts and theories in physical, life, and earth and space sciences; science inquiry; science with mathematics and technology; science in personal and social perspectives; the nature and history of science; unifying concepts or common themes; and scientific habits of mind.

Many people were involved in the development of national standards documents to build broad support and reach general agreement among all groups of educators involved in science education (AAAS, 1989, 1993; NRC, 1996). Such support and agreement, however, does not guarantee that a consensus exists among science educators (Collins, 1998). Scientific literacy has multiple meanings from theoretical and historical perspectives (Koballa, Kemp, & Evans, 1997; Shamos, 1995; Trowbridge & Bybee, 1996). In a similar manner, university professors in science or science education, generally regarded as experts in their areas, may have particular views or perceptions of scientific literacy.

K-12 science teachers are educated and influenced by science professors and science education professors in teacher preparation programs. Science professors who teach introductory courses often impact prospective teachers' understanding of what science is (Steen, 1991; Young & Kellogg, 1993), and science education professors' impact the pedagogy practices of science teachers (Krajcik & Penick, 1989). Thus, both science professors and science education professors influence the development of prospective teachers in science education. Considering that formal preparation of prospective teachers occurs in college, it is important to understand professors' perceptions of scientific literacy and their efforts (or lack of efforts) to promote scientific literacy with prospective teachers.

Studies consistently indicate that elementary school teachers are not adequately prepared to teach science (Hoffman & Stage, 1993; Steen, 1991; Worthy, 1989). Some studies place the blame on college and university professors. Professors tend to teach as they were taught, usually with

lecture-based methods that emphasize rote learning of disconnected facts (Heikkinen, McDevitt, & Stone, 1992; Young & Kellogg, 1993). Future elementary teachers will most likely teach as they were taught and teach the material they were taught. Professors often fail to provide an example and a foundation to promote scientific literacy for prospective elementary teachers.

Other studies blame teacher education programs for inadequate preparation of elementary school teachers in science (Ginns & Watters, 1995; Mechling, 1982; Prisk & Staver, 1982). Students preparing for an elementary education career often take a few introductory science courses and one science teaching methods course. The introductory science courses are sometimes designed to "weed out" non-science students, instead of providing an awareness of the wide possibilities and opportunities of science (Sagan, 1990). If professors do not approach science education as an opportunity for all students, the attitudes of future elementary teachers may be affected by this less than positive experience. For many prospective teachers, introductory science and science methods courses are often the last science experience before beginning teaching careers.

The current science education reform efforts define standards of scientific literacy for the general population. Reforms involving significant changes need to be evaluated to examine whether or not the national standards are considered or emphasized in actual science instruction. Thus, there is a need to understand the perceptions of scientific literacy and science education reform held by professors who, in turn, impact prospective teachers. A study of professors is an important step in this evaluation process because it can provide information about the relevance of the

standards of scientific literacy and provide a way to evaluate science education reform (Vacc, 1995).

This study examined the perceptions of scientific literacy and elementary school teacher preparation held by science professors and science education professors. The study compared similarities and differences in perceptions between science professors and science education professors. The study examined two research questions, each with a set of specific questions.

Question 1: What are the professor's perceptions of scientific literacy?

a. definitions of scientific literacy and its components, and
b. implementation of scientific literacy in their own teaching.

Question 2: What are the professor's perceptions of scientific literacy among elementary teachers?

a. opinions of the level of science preparedness among elementary teachers and of factors contributing to unprepared teachers,
b. suggestions for enhancing elementary teacher preparation, and
c. suggestions for ways they can promote scientific literacy of prospective elementary teachers.

Method

Participants and Research Setting

The population for this study consisted of introductory level science professors and elementary science education professors from nine institutions of a large state university system in a southeastern state. In the science departments at each university, the targeted professors were those

identified as instructors of introductory level biology, chemistry, or physics courses. In the elementary education department at each university, the targeted professors were those identified as instructors of science methods courses in the elementary teacher preparation program. Participants were randomly selected from the lists of targeted professors provided by the individual departments. From the potential pool, the study solicited volunteers for participation. The total sample of 31 participants consisted of 16 science professors (nine life science and seven physical science) and 15 science education professors. Up to four (with no more than two from each category) science professors and science education professors were selected from each of the nine institutions. The information about the participants is presented in Table 1.

Instrument

The interview protocol consisted of questions in three areas: (a) biographical information, (b) definitions of scientific literacy and its components, and (c) perceptions of elementary school teacher preparation. The protocol was developed by the researcher, with a team of specialists. These specialists included a scientist, science educators, and teacher educators. The protocol was pre-tested by two science education professors and five science professors in biology, chemistry, geology, and physics at a large private university in a southeastern state. They assessed the interview questions in terms of what was being asked, whether the questions were clear and easy to understand, and how they would respond to the questions. The interview protocol was designed to obtain professors' views

Table 1
Participants in the Sample (Frequencies and Means)

		Science Professors (n = 16)	Education Professors (n = 15)	Total (n = 31)
Gender	Male	13	8	21
	Female	3	7	10
Title	Professor	7	6	13
	Associate Professor	6	5	11
	Assistant Professor	1	2	3
	Adjunct or Lecturer	2	2	4
Primary Job Responsibility	Teaching	10	8	18
	Administration	0	1	1
	Teaching/Research	4	6	10
	Teaching/Administration	2	0	2
Degree	Bachelor's in science field	14	9	23
	Bachelor's in secondary science education	1	5	6
	Master's in science field	10	5	15
	Master's in (secondary) science education	0	6	6
	Doctorate in science	15	1	16
	Doctorate in science education	0	10	10
	Doctorate in education	0	2	2
Experience with Pre- or In-Service Teachers	Yes	7	15	22
	No	9	0	9

	Mean	Mean	Mean
Number of Courses Taught Per Semester	2.3	2.8	2.5
Number of Years Teaching at Post-Secondary Level	23.3	14.6	19.0
Number of Years Teaching at Current University	20.2	14.4	17.3
Number of Years Teaching Introductory Science or Elementary Methods Courses	22.5	12.7	17.6
Number of Years Teaching at K-12 Level	0.9	7.9	4.4

or opinions as professionals and experts involved in science education. The issues were non-threatening, so their views or opinions on these issues were not likely to lead to socially desirable responses. Some of the interview items were designed to confirm each other; therefore, responses were expected to be consistent among these items.

Data Collection and Analysis

The study employed qualitative interview methods. Although there are some problems inherent in this interview method, such as time constraints, privacy issues, and inaccurate or false self-reports, the benefits outweighed these problems in this study (McCracken, 1988). An initial contact letter was sent to the professors who agreed to participate. All interviews were completed by the researcher in fall 1996. Interviews were allotted 30 minutes each, although some interviews lasted about an hour. With the consent of the participants, the interviews were tape recorded over the phone and later transcribed. In addition to individual interviews, professors provided copies of course documents, including the course syllabi and relevant materials. These documents were used to examine what the professors did to promote scientific literacy in their own teaching. The documents were also used for triangulation of the professors' views of scientific literacy through interviews (Denzin & Lincoln, 1994).

Interview responses and course documents were analyzed to identify major patterns and themes (Bogdan & Biklen, 1992; Strauss & Corbin, 1990). Using the constant comparative method (Strauss & Corbin, 1990), the statements were categorized into major patterns and themes. Frequency

tables were developed, highlighting comparisons between science professors and science education professors. Quotations from interviews and examples of course documents to confirm or disconfirm the patterns were obtained. Data analysis was conducted by two coders. After reaching 90% agreement for approximately 30% of the data sets, one coder completed data analysis while consulting with the other coder on all unclear or unambiguous responses.

Results

Results are presented for each research question in terms of both frequency tables for major patterns and examples to illustrate these patterns. Similarities and differences between science professors and science education professors are highlighted.

Perceptions of Scientific Literacy

Definitions and components of scientific literacy. Because professors responses were generally consistent with the components of scientific literacy in the NSES and Project 2061 documents, these components were used as the framework to organize the responses (Table 2).

Science professors mentioned science knowledge (38%) more frequently than any other component in their definitions of scientific literacy. Many emphasized the knowledge of current science issues and topics, such as the ability to read and understand scientific material on the latest advances or discoveries in science Some emphasized science concepts, terminology, and facts as basic foundations of chemistry, physics, biology, and geology.

Table 2
Professors' Definitions and Components of Scientific Literacy (Frequencies and Percentages)

General Areas of Scientific Literacy	Definition			Components		
	Science Profs (n = 16)	Educ. Profs (n = 15)	Total (n = 31)	Science Profs (n = 16)	Educ. Profs (n = 15)	Tota (n = 3
Science Inquiry	7 (14%)	18 (31%)	25 (23%)	4 (7%)	26 (39%)	30 (25
Use scientific method/test hypothesis	3	9		0	7	
Form questions/observe/collect data/explain	1	5		2	7	
Ability to communicate science/results	1	1		0	4	
Reason/use logic/critical thinking	2	3		2	8	
Science Knowledge	19 (38%)	12 (20%)	29 (28%)	22 (41%)	15 (22%)	37 (31
Main science concepts/terms/facts	6	9		12	12	
Current science issues/topics	12	1		3	1	
Main fields of science	0	0		6	2	
Cause and effect/interrelationships	1	1		1	0	
Science-Mathematics-Technology	1 (2%)	6 (10%)	7 (6%)	4 (7%)	2 (3%)	6 (5%
Relationship of science/math/technology	0	4		0	1	
Knowledge of mathematics/statistics	1	0		4	1	
Relationship to other subjects	0	2		0	0	
Science in Personal and Social Perspectives	14 (28%)	14 (24%)	28 (26%)	10 (19%)	10 (15%)	20 (17%
Relationship of science to society/self	3	7		3	2	
Read/understand science in news media	8	2		3	0	
Make decisions on current science topics	3	5		1	5	
Know where to access information	0	0		3	3	
Nature and History of Science	9 (18%)	8 (14%)	17 (16%)	14 (26%)	12 (18%)	26 (21%
Science as a way of knowing/thinking	1	2		2	2	
Know what science is/how science works	3	1		2	3	
Know science as changing/dynamic/tentative	1	1		1	3	
Know pseudo from true science	3	0		5	1	
Attitude (appreciation/curiosity/skepticism)	1	4		4	3	
Unifying Concepts and Processes	0 (0%)	1 (1%)	1 (1%)	0 (0%)	2 (3%)	2 (1%
Total	50	59	109	54	67	121

Science professors also stressed science in personal and social perspectives (28%), such as knowing how science is related and applied to many of the personal and social issues discussed in newspapers or general purpose magazines. Some emphasized the nature and history of science (18%), and one said that people should "not believe everything they read because much of it is not based on much evidence and be able to discern scientific ideas from non-scientific ideas."

Science education professors stressed science inquiry most frequently (31%). Many emphasized the ability to use the scientific method, reason, use logic, think critically; and to observe the world; find patterns and relationships; collect data that can be formed into patterns and relationships; and test these hypothesized relationships. They also emphasized science in personal and social perspectives (24%), as one said, "A person needs to understand man's impact on the world and how to vote knowledgeably to continue with our world." Some stressed science knowledge (20%), as one said that people should "have some degree of science content and know the general big ideas of science content."

Implementation of scientific literacy. Professors self-reports were analyzed in terms of main activities used to implement scientific literacy in their own teaching (Table 3).

Science professors stated the use of lecture-based activities most frequently (43%). In their lectures, many used overheads, outlines, and diagrams to teach science terms and definitions in the text. They also reported the use of student participation activities (39%), including class discussion on current science topics. One professor described the use of

daily examples from the newspaper or prominent news magazines about discoveries on subjects that are being covered in class.

Science education professors reported the use of student participation activities almost exclusively (81%). They cited the use of labs experimentation, and problem-solving to provide hands-on inquiry and discovery . . . a personal experience in an environment that nurtures inquiry One said, "we could talk about the facts, but much more useful is the ability to collect data, form patterns and relationships, and see rules."

Table 3
Professors' Self-reports of Activities in Their Teaching (Frequencies and Percentages)

	Science Professors (n = 16)	Education Professors (n = 15)	Total (n = 31)
Student Participation Activities	9 (39%)	17 (81%)	26 (59%)
Labs/experiments/problem-solving	1	10	
Discussion of current science topics	6	1	
Cooperative learning activities	1	4	
Lecture-Based Activities	10 (43%)	2 (10%)	12 (27%)
Lecture/explanation	6	0	
Encourage/teach questioning techniques	2	2	
Written Assignments	2 (9%)	1 (5%)	3 (7%)
Other	0 (0%)	1 (5%)	1 (2%)
None (Did not or could not give example)	2 (9%)	0 (0%)	2 (5%)
Total *	23	21	44

Note. The total adds up to more than 31 because each respondent gave more than one response to an open-ended question.

The self-report results were generally consistent with the results based on course documents. With science professors, lecture-based activities were indicated most frequently (frequency = 26, 55%), along with student participation activities (frequency = 7, 24%) and written problems and exercises (frequency = 6, 21%). With science education professors, student participation activities were indicated most frequently (frequency = 32, 65%), followed by some lecture type activities, usually as an introduction to provide background for another activity (frequency = 12, 35%).

Professors Perceptions of Elementary Teacher Preparation

Opinions of elementary teachers level of science preparedness. Professors' responses were analyzed in terms of two categories, prepared and unprepared. If professors indicated a lack of preparedness among elementary teachers, they were asked to identify possible contributors to this lack of preparation (Table 4).

Many of the science professors (69%) and science education professors (60%) expressed that elementary teachers were unprepared to teach science. No one expressed that elementary teachers were generally prepared to teach science. They said that many elementary teachers are scared of science, and that although the teachers are familiar with a lot of activities, there is question as to whether their knowledge and background in science is adequate.

In terms of contributors to lack of elementary teachers preparedness, science professors mentioned teachers most frequently (50%). Some pointed out teachers' lack of science knowledge and fear of science, as one

Table 4
Professors' Opinions of Elementary Teachers' Level of Science Preparedness (Frequencies and Percentages)

	Science Professors (n = 16)	Education Professors (n = 15)	Total (n = 31)
Overall Opinion			
Generally prepared	0 (0%)	0 (0%)	0 (0%)
Some prepared, some unprepared	3 (19%)	3 (20%)	6 (19%)
Generally unprepared	11 (69%)	9 (60%)	20 (65%)
Don't know/Not prepared for the issue	2 (12%)	3 (20%)	5 (16%)
Contributors to Poor Preparations			
Universities	11 (37%)	17 (52%)	28 (44%)
Insufficient science requirements	9	8	
Inadequate training in science methods	1	6	
Teachers	15 (50%)	12 (36%)	27 (43%)
Lack of science knowledge	7	5	
Fear of science	4	3	
Lack of understanding of personal meaning of science	2	4	
Schools	4 (13%)	4 (12%)	8 (13%)
Not departmentalized/poorly structured	3	4	
Total*	30	33	63

Note. The total adds up to more than 31 because each respondent gave more than one response to an open-ended question

said, "Teachers don't understand why they are teaching what they're teaching because they haven't integrated why science is important and why it is important to them." They also pointed out problems at the university level (37%). Many indicated insufficient science requirements. One said, "Teachers are always placed in a watered-down science course." Another said, "Universities place too much emphasis on teaching methods and not enough on science content. Methods don't help when you don't know the material."

Science education professors mentioned universities most frequently (52%) as contributors to elementary teachers unpreparedness. Many indicated insufficient requirements in both science content and science methods at the university level. One said, "Most colleges of education let you get by with one survey science course, so they haven't been exposed to develop a decent understanding of science." Another said, "One methods course is not enough to prepare them to teach science. " Science education professors also pointed out teachers lack of science knowledge and fear of science (36%).

Suggestions for enhancing elementary teacher preparation. Professors responses were analyzed in terms of three categories: (a) changes at universities, (b) changes with teachers, and (c) changes in schools and the state (Table 5).

When asked how to enhance elementary teacher preparation, many of the science professors suggested changes with teachers (43%), stressing the importance of teachers' solid knowledge of K-6 science content. Others proposed changes at universities (38%), focusing on more science content courses, such as more content and less methodology and more science courses designed especially for elementary education majors.

Most of the science education professors recommended changes at universities (77%). Several mentioned more science content courses, such as "a science content class that provides an overview, a basic knowledge of science, that there isn't time for in the methods class." A few mentioned more collaboration between education and sciences, especially among the professors who teach the content and methods courses. Several also

suggested changes with teachers (23%), particularly teachers' knowledge of K-6 science content. One said that teachers need "to integrate science with other subjects that are already emphasized (reading and math), and to help children develop higher-order thinking skills while strengthening reading and math skills."

Table 5
Professors' Suggestions for Enhancing Elementary Teacher Preparation (Frequencies and Percentages)

	Science Professors (n = 16)	Education Professors (n = 15)	Total (n = 31)
Changes at Universities	8 (38%)	17 (77%)	25 (58%)
More science content courses	4	6	
More science research experiences	1	3	
More integrated elementary curriculum	0	3	
Collaboration between sciences and education	1	2	
Changes with Teachers	9 (43%)	5 (23%)	14 (32%)
Knowledge of K-6 science content	7	3	
Training in subject areas (departmentalization)	1	2	
Changes in Schools and the State	2 (10%)	0 (0%)	2 (5%)
No idea	2 (10%)	0 (0%)	2 (5%)
Total*	21	22	43

Note. The total adds up to more than 31 because each respondent gave more than one response to an open-ended question

Suggestions about own efforts. Professors' statements about what they could do specifically to promote scientific literacy of prospective elementary teachers were analyzed in terms of (a) changes at the university level and (b) changes in their own teaching (Table 6).

Many of the science professors suggested changes in their own teaching (43%), stressing the importance of hands-on, laboratory, use of

everyday events and objects, and research activities. They also recommended changes at the university level (38%), including more science course requirements, especially for upper level courses and special science courses designed for the elementary education majors.

Table 6
Professors' Suggestions for Their Own Efforts (Frequencies and Percentages)

	Science Professors (n = 16)	Education Professors (n = 15)	Total (n = 31)
Changes at the University Level	8 (38%)	4 (19%)	12 (28%)
Collaboration between sciences and education	1	2	
Science course designed for elementary education majors	2	1	
More courses and better sequencing	3	0	
Changes in Their Own Teaching	9 (43%)	16 (76%)	25 (60%)
Hands-on, laboratory, field experiences	7	5	
Modeling	0	4	
Science Knowledge	1	3	
No idea	4 (19%)	1 (5%)	5 (12%)
Total*	21	21	42

Note. The total adds up to more than 31 because each respondent gave more than one response to an open-ended question

Many of the science education professors suggested changes in their own teaching (76%), including more emphasis on hands-on, field experiences, modeling, and science knowledge. Several suggested changes at the university level (19%). Two professors stressed collaboration between education and sciences, such as more cross-articulation between Schools of

Arts and Sciences and Schools of Education, including the co-teaching o courses in methods and content.

Conclusions and Discussion

Science professors and science education professors, as a group, tended to define scientific literacy and its components in broad terms. Both groups identified science knowledge, inquiry, and science in personal and social perspectives as major components of scientific literacy, along with the nature and history of science and science-mathematics-technology connections. Despite a significant level of agreements, the results indicate major differences between the two groups. Science professors emphasized science knowledge more strongly than other components of scientific literacy; whereas, science education professors emphasized science inquiry. Consistent with their views of scientific literacy, science professors frequently used lecture-based activities in their own teaching; whereas, science education professors used student participation activities predominantly (Heikkinen, McDevitt, & Stone, 1992; Young & Kellogg, 1993). These differences reflect the differences in emphasis between the NSES and Project 2061 (AAAS, 1996, 1997; Lee, 1998; Lee & Paik, 2000). The NSES emphasizes that "scientific inquiry is at the heart of science and science learning" (NRC, 1996, p. 15); whereas, Project 2061 highlights "both scientific knowledge of the world and scientific habits of mind" (AAAS, 1989, p. 190). In this study, science professors tended to be more in line

with Project 2061 with its focus on science knowledge; whereas, science education professors with the NSES with its focus on science inquiry.

Both science professors and science education professors indicated that elementary teachers were generally not prepared to teach science (Hoffman & Stage, 1993; Steen, 1991; Worthy, 1989). Many professors indicated elementary teacher's lack of science knowledge and fear of science. Both groups also pointed out that problems and solutions for teachers' lack of preparation resided in a complex set of factors involving universities, professors, teachers, and schools (Ginns & Watters, 1995; Heikkinnen, McDevitt, & Stone, 1992; Mechling, 1982; Prisk & Staver, 1982; Young & Kellogg, 1993).

There were noticeable differences in emphasis between the two groups. Science professors attributed teachers' lack of preparation first to teachers and then to universities. To improve elementary teacher preparation, they suggested changes with teachers first and then changes at universities. When asked what they could do to enhance scientific literacy of elementary teachers, they suggested changes at the university level first and then changes in their own teaching. In contrast, science education professors attributed teachers' lack of preparation first to universities and then to teachers. They suggested changes at universities before expecting changes with teachers. They also emphasized what they could do in their own teaching to enhance scientific literacy of teachers. Thus, science professors seemed to perceive themselves as outsiders to reform efforts; whereas, science education professors perceived themselves as active participants.

. Despite differences, the two groups also expressed agreements. To improve elementary teachers science knowledge, both groups emphasized more science content courses at universities and more student participation in their own courses. In addition, some professors expressed a desire for more collaboration between science professors and science education professors as well as between Schools of Arts and Sciences and Schools of Education.

With the current emphasis on scientific literacy for all students, special attention needs to be given to university professors involved in the preparation of the K-12 teachers. If the NSES, Project 2061, and other national documents provide the foundation for science education reform, we need to examine how the professors perceive and implement the reform. Information about similarities and differences between science professors and science education professors offers valuable insights toward establishing collaborative relationships between the two groups. Collaborative efforts at both individual and institutional levels can improve elementary teacher preparation programs and strengthen shared responsibility and accountability in science education reform.

The results of this study are limited, as it relied primarily on self-reports of professors' perceptions. Multiple sources of data should be incorporated to increase the validity of the self-report data and to offer additional insights to address the problems associated with elementary teacher preparation. In this study, the content analysis of course syllabi and related materials generally confirmed professors' views of scientific

literacy. Observations of teaching would have provided valuable information for triangulation of self-report and content analysis data.

The need for further research is evident based on this study. Considering that science professors emphasized science knowledge and science education professors emphasized inquiry, more in-depth research comparing the two groups would provide further understanding of why these differences exist. Because the science professors in the study were most often instructors of the lecture segments of introductory science courses, further studies might include instructors of laboratory segments. Also, because a majority of college graduates take introductory science courses at the community colleges level, these professors will provide additional insights about the science professor population. Finally, further studies might examine the extent to which science professors and science education professors incorporate reform-oriented practices in their teaching. These research efforts will contribute to a knowledge base in enhancing the scientific literacy of prospective elementary teachers and their students.

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